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Physical Activity in Daily Life Assessed by an Accelerometer in Kidney Transplant Recipients and Hemodialysis Patients

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ABSTRACT

Background. Sedentary lifestyle is a problem among hemodialysis (HD) patients, potentially attenuated after kidney transplantation. However, the effect of kidney transplantation on physical activity has not been thoroughly investigated.

Objective. This study sought to evaluate the physical activity in daily life in kidney transplant recipients (KTRs) compared with HD patients and to explore its relationship with clinical variables.

Methods. A cross-sectional study enrolled KTRs who received transplants at least 6 months before the study (N = 23; 48.3 ± 10.3 years) and patients undergoing HD for at least 6 months (N = 20; 47.3 ± 12.6 years). Time spent in different activities (walking, standing, sitting, and lying down) and number of steps taken, measured by a multiaxial accelerometer used for 12 h/d on 2 consecutive days for KTRs and on 4 consecutive days for HD patients, were evaluated.

Results. KTRs engaged in more active time per day (sum of walking and standing time) than HD patients (311 ± 87 vs 196 ± 54 min/d; $P = .001$), with longer walking (106 ± 53 vs 70 ± 27 min/d; $P = .008$) and standing time (205 ± 55 vs 126 ± 42 min/d; $P < .001$). Sixty-five percent of KTRs were classified as active (>7500 steps/d) compared with only 20% of the HD group ($P < .05$). The multivariate analysis showed that time posttransplantation was significantly associated with walking time and active time.

Conclusions. By using an accelerometer, a precise method, this study showed that KTRs are significantly more active in daily life than HD patients, and that daily physical activity increases with time since transplantation.

SEDENTARY lifestyle is associated with 2 million deaths per year worldwide and contributes to the development and progression of several chronic diseases, notably those of the cardiovascular system [1]. This type of behavior is even worse among patients with end-stage renal disease, who have an elevated risk of cardiovascular events or mortality and are more sedentary than the general population [2–4]. There are several factors promoting a sedentary lifestyle in patients on regular hemodialysis (HD): anemia, functional and structural muscle abnormalities, uremia, inflammation, hyperparathyroidism, reduced secretion of testosterone, and malnutrition [5]. Moreover, the time spent in dialysis sessions makes these subjects less active in their daily lives than healthy individuals [6].

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Many factors associated with a sedentary lifestyle in HD patients, such as anemia, uremia, and the 12 hours per week spent on dialysis, may be corrected by a kidney transplant. However, adverse effects of immunosuppressive drugs, recurrent infections, and bone and muscle changes acquired during the dialysis treatment could contribute to inactivity in kidney transplant recipients (KTRs) [7,8]. The net result of all these factors on physical activity in KTRs is not well established.

There is an increasing interest in measuring the physical activity in daily life in different populations. However, among end-stage renal disease patients, most studies have used questionnaires, which are instruments with low accuracy, especially among subjects with light activities such as HD patients [9]. The accelerometer-based activity monitor used in this study measures time spent on different activities (walking, standing, sitting, and lying), number of steps taken, and movement intensity, and it has been validated in patients with different chronic diseases [10,11]. Therefore, the aim of the present study was to evaluate the physical activities in daily life in KTRs compared with HD patients using a triaxial accelerometer. Furthermore, we investigated the relationship between physical activities in daily life and the potentially related variables.

SUBJECTS AND METHODS

Study Design

We conducted a cross-sectional study of KTRs and HD patients at the Nephrology Unit of the University Hospital of the Federal University of Juiz de Fora, Brazil. Patients included in the study were recruited and evaluated between January 2012 and March 2013.

Participants

All KTRs who had received transplants at least 6 months before the study and all patients undergoing HD 3 times per week for at least 6 months from our unit were assessed for eligibility. In both groups, exclusion criteria were age <18 or >65 years, uncontrolled arrhythmia, hypertension, uncontrolled diabetes mellitus, unstable angina, severe respiratory disease, acute infection, severe renal osteodystrophy, neurologic or musculoskeletal disturbance, and involvement in any kind of exercise training in the preceding 6 months. Patients who lived in other cities also were excluded because of the difficulty in coming to the unit on the nondialysis days. The study protocol was approved by the Research Ethics Committee of the Federal University of Juiz de Fora, and it is in accordance with the Declaration of Istanbul. All patients signed an informed consent form before participation.

Measurements and Outcomes

General and Laboratory Data. Demographic and clinical data, including sex, age, time on HD, time posttransplantation, type of donor, comorbidities, body mass index (BMI), education level, and family income were collected through medical records and self-report. Hemoglobin, creatinine, urea, phosphorus, calcium, albumin, and iron were measured. For the HD patients, measurements were done before the first HD session of the week. The adequacy of dialysis was calculated by Kt/V [12].

Physical Activities in Daily Life by Accelerometer. A triaxial accelerometer (DynaPort Activity Monitor; McRoberts BV, The Hague, Netherlands) was used to assess physical activity in daily life. The device measures the time spent walking, standing, sitting, and lying down, and the number of steps taken. Active time was calculated as the sum of walking and standing time. The accelerometer was used for 12 h/d in both groups, beginning when the patient woke up. The HD patients used it for 4 consecutive weekdays that corresponded to 2 dialysis days and 2 non-dialysis days, and KTRs were monitored for 2 consecutive weekdays; they were instructed to maintain normal activities of daily life. According to the numbers of steps taken, the patients were classified as sedentary (<5000 steps/d), somewhat active (5000 to 7499 steps/d), and active (≥7500 steps/d) [13].

Six-Minute Walk Test and Peripheral Muscle Strength. The analysis of physical functioning was performed by a 6-minute walk test (6MWT) following the recommendations of the American Thoracic Society [14]. The HD patients performed the 6MWT on a nondialysis day. Isometric handgrip strength was measured with a hydraulic hand dynamometer (Jamar Hydraulic Hand Dynamometer, Sammons Preston, Rolyan, Illinois, USA). At least 3 trials were conducted, with a rest period of at least 1 minute between trials; the highest value was used in the analyses [15]. In KTRs without arterial venous (AV) fistula, the measurements were made on the dominant side, whereas in patients with AV fistula, the measurements were performed on the nonfistula side. The sit-to-stand test was used to assess lower extremity muscle strength. Patients were instructed to stand up and sit back down from a seated position, with arms folded across the chest, on a standard 44-cm straight-back chair with no armrests. The number of repetitions achieved at the end of 60 seconds was recorded [16]. All of the force measurements were performed on nondialysis days for the HD patients.

Statistical Analysis

Data were shown as mean and standard deviation (SD), median and interquartile range (IQR) or number and percentage. Normal distribution was checked with the Kolmogorov-Smirnov test. Comparisons between groups were performed by independent-sample t test for normally distributed variables, by the Mann-Whitney U test for variables that were not normally distributed, and by the χ^2 test for categorical variables. Pearson coefficient was used for the study of the correlations, except for those involving family income, time on HD, time posttransplantation, hemoglobin, phosphorus, SF-36 domains, and sit-to-stand test, all of which were evaluated by Spearman coefficient. Multivariate linear regression analysis was performed when significant correlations were found between the accelerometer outcomes and clinical data. Those were used as adjusting variables regarding the group differences in activity time estimation. The level of significance was set at $P < .05$. All statistical analyses were performed using SPSS 17.0 for Windows (SPSS Inc., Chicago, Illinois, USA).

RESULTS

One hundred and thirty-two KTRs and 40 HD patients were assessed for inclusion eligibility; 104 KTRs not satisfying the inclusion criteria were excluded (74 lived in another city, 4 were under 18 years old, 12 were older than 65, 8 had less than 6 months of transplantation, 6 had musculoskeletal disease) and 5 patients declined to participate in the study.

Table 1. Demographic and Clinical Characteristics of Participants

Characteristics	KTRs (n = 23)	HD (n = 20)	P Value
Age (y)	48.3 ± 10.3	47.3 ± 12.6	.76
Male	11 (48%)	11 (55%)	.63
Race, nonwhite	12 (52%)	11 (58%)	.71
Body mass index (kg/m^2)	24.7 ± 4.0	22.9 ± 3.9	.13
Educational level (y)			.63
<4	6 (26%)	3 (15%)	
4–8	6 (26%)	7 (35%)	
>8	11 (48%)	10 (50%)	
Family income (USD/mos)	682 (841)	578 (820)	.83
Time on hemodialysis (mos)	15 (28)*	48 (85)	<.001
Time posttransplantation (mos)	67.9 ± 64.6		
Comorbid condition			.38
Diabetes	5 (22%)	2 (10%)	
Hypertension	15 (65%)	14 (70%)	
Cardiovascular disease	2 (9%)	4 (20%)	
6-minute walk test (meters)	559 ± 45	520 ± 95	.15
Isometric handgrip strength (kg force)	33.4 ± 10.7	34.0 ± 9.4	.88
Sit-to-stand test (events per minute)	27 (6)	26 (7)	.82
Creatinine (mg/dL)	1.6 ± 0.8	12.2 ± 5.4	<.001
Hemoglobin (mg/dL)	12.5 (2.0)	10.4 (3.5)	.007
Albumin (mg/dL)	4.17 ± 0.51	3.76 ± 0.29	.016
Serum iron (μ/dL)	87.7 ± 27.8	66.6 ± 25.2	.02
Calcium (mg/dL)	10.2 ± 1.1	9.4 ± 0.8	.006
Phosphorus (mg/dL)	3.6 (1.2)	5.7 (2.5)	<.001
Kt/V		1.50 ± 0.20	

Data are presented as mean ± standard deviation, median (interquartile range), or number (percent) as appropriate. Continuous variables normally distributed were compared using the unpaired *t* test, and those not normally distributed were compared by the Mann-Whitney *U* test. Categorical variables were compared by the χ^2 test.

Abbreviations: KTR, kidney transplantation recipients; HD, hemodialysis; Kt/V, adequacy of dialysis.

*Time spent on hemodialysis before transplantation.

Among the HD patients, 13 were excluded (2 were older than 65, 3 had musculoskeletal disease, 2 had neurologic disease, 2 had unstable angina, 1 had uncontrolled arrhythmia), and 7 declined to participate. As a result, 23 KTRs and 20 HD patients were included in the study.

Sex, age, BMI, education level, family income, 6MWT, and peripheral muscle strength were similar across groups. The levels of hemoglobin, serum iron, calcium, and phosphorus were significantly different between KTRs and HD patients. Seventy-eight percent of the KTRs received their graft from a living donor. The Kt/V in the HD group was 1.50 ± 0.20, indicating that the patients were adequately dialyzed, and 100% of them were receiving erythropoietin (Table 1).

The KTRs were active a greater part of the day than HD patients (311 ± 87 vs 196 ± 54 min/d; $P = .001$), with longer walking (106 ± 53 vs 70 ± 27 min/d; $P = .008$) and standing time (205 ± 55 vs 126 ± 42 min/d; $P < .001$) (Fig 1). The KTRs spent less time lying down per day than HD patients (86 ± 106 vs 197 ± 92 min/d; $P < .001$). The KTRs also took more steps per day compared with HD patients (9705 ± 4902 vs 5678 ± 2178; $P = .005$). Fifteen patients with transplants (65%) reached the goal of 7500 steps/d, therefore achieving the classification of active, whereas only 4 (20%) in the HD group achieved this number ($P < .05$). Additionally, 26% of the KTRs were classified as sedentary, compared with 45% among HD patients. Even when compared with HD patients on nondialysis days, KTRs were more active and spent more time standing. When the comparison was made on dialysis days, the differences were more pronounced, with KTRs significantly more active, with longer walking and standing times (Table 2).

Walking time correlated positively with time posttransplantation ($r = 0.42$) and serum calcium level ($r = 0.35$), and negatively with family income ($r = 0.31$). Active time correlated positively with time posttransplantation ($r = 0.51$), serum calcium level ($r = 0.55$), serum albumin ($r = 0.39$), and hemoglobin ($r = 0.33$). Multivariate regression models for walking time and active time were adjusted for those significant correlations to assess the group effect, KTRs vs HD. Time posttransplantation remained significantly associated with walking time (coefficient 0.22 min/d per month, 95% confidence interval (CI) 0.02 to 0.43) and active time (coefficient 0.41 min/d per month, 95% CI 0.09 to 0.73). Furthermore, the calcium level remained associated with active time (coefficient 27.25 min/d per mg/dL, 95% CI 5.36 to 49.14). In both models, group adjusted effects were significant, with KTR patients spending 32.24 (CI 3.27 to 61.2) walking min/d and 92.7 (CI 47.5 to 137.9) active min/d more than the HD patients.

DISCUSSION

The present study showed that KTRs are significantly more active in physical activities of daily life than HD patients. They spent more time walking or standing and take more steps. The difference between KTRs and HD patients was greater on dialysis days, but was also present when the groups were compared on nondialysis days. In addition, 65% of KTRs were classified as active, according to the number of steps taken, compared with only 20% of HD patients.

These results are hardly surprising because other studies have shown that the rate of physical activity in HD patients is low [4,17]. These individuals have many circumstantial factors associated with inactivity, and many of them can be reversed or improved with the transplantation. In fact, Nielens et al. demonstrated, using questionnaires, an increase of 30% in the level of physical activity in a cohort of patients receiving kidney transplants, which remained unchanged for 5 years posttransplantation [18]. Although questionnaires have been used to evaluate physical activity of daily living, they are not accurate and have a large variability across different factors, such as age, educational level, and cognitive capacity. They are especially poor in the assessment of low-intensity activities, which are common among patients with chronic diseases, including chronic kidney disease [9,19].

To assess the level of physical activity of daily living, we used a triaxial accelerometer that has greater accuracy and

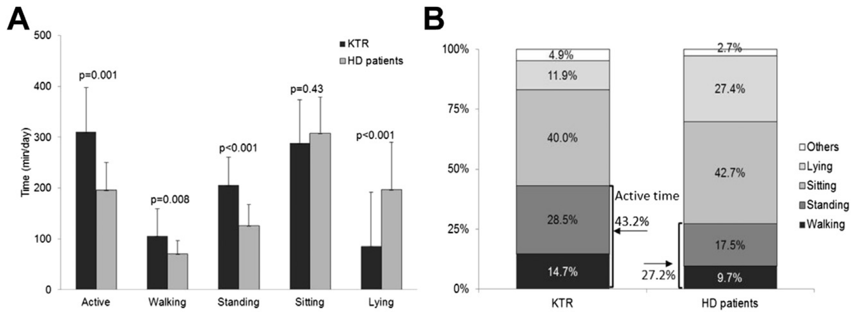

Fig 1. **(A)** Time spent per day (minutes) on different activities. Groups were compared by *t* test. **(B)** The percentages of time spent in each activity in kidney transplantation recipients (KTRs) and hemodialysis (HD) patients during the day. Others include cycling or undetermined.

less variability compared with other measurement tools, such as questionnaires, pedometers, and other devices that measure the physical activity level through arbitrary units or estimate energy expenditure [20]. The accelerometer stores data continuously over a long period and does not interfere with the daily routine of the individual. It has been validated for use with different chronic diseases, and the results are comparable to video analysis, which is considered the gold standard. Because of its greater sensitivity in detecting mild activities, it is particularly useful in the study of populations characterized by inactivity [9,11,20]. To our knowledge, this is the first study that objectively assessed physical activity in the daily life of KTRs and described detailed differences between them and HD patients, in terms of time spent on different activities and positions, as well as number of steps taken. We showed that KTRs remained active, ie, walking or standing, for 43% of the time, compared with 27% among the HD patients. KTRs spent 34% more time walking than HD patients, and took 42% more steps. In addition, HD patients remained lying down more than twice as long as KTRs.

Knowing the importance of physical activity, different medical societies and the World Health Organization have established daily levels of physical activity that should be met [21]. Some of these recommendations are based on the number of steps taken per day; 7500 steps/d is the minimum required to characterize an individual as active. In addition, it has been established that reaching levels as high as 10,000 or 12,500 steps/d results in greater benefits [13]. Accordingly, in our study, 65% of transplant patients reached the 7500 steps/d recommended, whereas only 20% of the HD patients met this recommendation; 43% of the KTRs, but none of the HD patients, reached 10,000 steps/d. As in the general population, physical activity benefits both KTRs and HD patients. Among KTRs, regular physical activity improves graft function, increases exercise capacity, and enhances quality of life [22,23]. Among HD patients, those who are active present higher dialysis efficacy, better control of arterial pressure and metabolic profile, and better quality of life [24,25]. In both groups, physical activity has been associated with lower risk of death, either from any cause or from cardiovascular causes [26–28]. The fact that physical inactivity is lower among KTRs can be seen as an advantage in this form of renal replacement therapy. However, even among them there are a proportion of sedentary individuals who must be identified and encouraged to change their lifestyle.

Hemodialysis patients present different features that contribute to a sedentary lifestyle, such as functional and structural alterations of skeletal muscles, uremia, inflammation, hyperparathyroidism, reduced secretion of testosterone, and malnutrition. Furthermore, the dialysis itself increases catabolism, which leads to a degraded physical condition [5,29]. Kidney transplantation can reverse many of these factors and eliminates the 12 h/week spent in dialysis, favoring, at least in theory, a more active lifestyle. In our study, physical activity was positively correlated with time posttransplantation, ie, patients who had had transplants for longer were more active. This result shows a progressive change in lifestyle after transplantation, which may be the result of different factors, such as improved functional capacity to perform physical activity or an increased availability of time to accomplish it. The positive correlation between active time and calcium was not a surprise because its higher levels are related to less impairment of bone metabolism, which is associated with being sedentary.

A limitation of the study is the small number of patients recruited from the same unit. Although the number was sufficient to identify differences in the level of physical activity in daily life between KTRs and HD patients, our sample may have been insufficient to reveal other factors that correlate with physical activity. Another potential limitation is the number of days during which the patients were monitored. KTRs were evaluated for 2 days and HD patients for 4 days, 2 dialysis and 2 nondialysis days. Although some investigators suggest that more than 2 days of monitoring is required to establish the pattern of physical activity in daily life, particularly in more active patients, such as KTRs, others have demonstrated that 2 days is enough, even with the use of pedometers, which have lower accuracy and higher variability than the accelerometer we used [9]. The possibility that patients changed their physical activity patterns during the period in which they were being monitored must also be considered, even though they had not been informed in detail about what was being monitored. Finally,

Table 2. Characteristics of Physical Activities in Daily Life

	KTRs (n = 23)	HD (n = 20) Nondialysis Days	HD (n = 20) Dialysis Days
Active time, min	311 ± 87*,†	247 ± 73	145 ± 62
Walking time, min	106 ± 53†	84 ± 37	56 ± 300
Standing time, min	205 ± 55*,†	163 ± 61	89 ± 37
Sitting time, min	288 ± 85	303 ± 87	311 ± 79
Lying time, min	86 ± 106†	146 ± 130	248 ± 89
Steps per day	9705 ± 4902†	6962 ± 3352	4396 ± 2034

Data are presented as mean ± standard deviation. The KTR group was compared with the HD group on nondialysis and on dialysis days by the unpaired *t* test.

Abbreviations: KTR, kidney transplantation recipients; HD, hemodialysis.

*$P < .05$ compared with nondialysis days.

†$P < .001$ compared with dialysis days.

not all variables potentially correlated with physical activity have been studied, and some, such as depression, may affect activity levels in certain patients.

In conclusion, based on the more accurate triaxial accelerometer measures, KTRs are markedly more active in daily life compared with HD patients. The longer time since transplantation and higher calcium levels are associated with higher physical activity levels in daily life.

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